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SOME THOUGHTS ON THE AGRICULTURAL EXPERIMENT STATION[1]

By Professor C. G. WILLIAMS

AGRICULTURAL EXPERIMENT STATION, WOOSTER, OHIO

IN so far as the United States is concerned, the first agricultural experiment station dates back only 57 years, Connecticut having the honor of establishing the first station in 1875.

It is of interest to note what called the experiment station into existence. In his first annual report, Director Atwater said: "There was bitter need of a better control of the trade in commercial fertilizers in the State. One of the chief arguments used in favor of the station has been that by its means a fertilizer control system could be introduced. The demand that its first efforts should be turned in this direction was imperative."

This report gives further proof of the reason for the existence of the station, in that 103 of its 108 pages are devoted to information regarding analyses, etc., of the commercial fertilizers on the market. Strange as it may now seem, there was a time when fertilizer manufacturers had a great deal of human nature about them of the unconverted sort. Some 200 samples were received and analyzed by the Connecticut station during this first year.

The questions put up by the Connecticut farmer of the seventies sound very much like those of the Mid-West farmer of 1932, as, for instance, "Are such and such brands of fertilizers of enough value to farmers in this county to warrant their purchase these hard times?"

For several years the staff of the Connecticut station consisted of the director and three or four chemists, whose principal work was to analyze fertilizers, soils, feeds and poisons. This does not mean that noth-

[1] Address of the president and chairman of Section O—Agriculture—American Association for the Advancement of Science, Atlantic City, December, 1932.

ing else was done, for it was during this early period that some of the most valuable agricultural research of the century was done by Director Atwater—in particular the discovery of the fixation of atmospheric nitrogen by legumes.

Just a word about the second agricultural experiment station, which was established two years later in North Carolina. Its staff consisted of a director, who was the chemist of the state board of agriculture, and three assistant chemists. Like the Connecticut station, its work for several years consisted principally of its analyses of soils, fertilizers and feeds and the examination of seeds.

In his first report Director Ledeaux says: "The Board of Agriculture has wisely refrained hitherto from ordering any field tests to be made at the station for the following reasons: (1) These experiments are very expensive. (2) They need to be conducted through a series of successive years to be worth anything. (3) Owing to the extreme diversity of soils in this state most results obtained would only benefit those farmers who lived near Chapel Hill, or had soil of similar character to ours."

The above statement is also repeated in the third annual report.

With a change in station directors the fourth year, we find the new director saying in his annual report: "Experience shows that chemical manures are used to best advantage only when their application is determined strictly by the results of experiments upon the land." However, no permanent field experiments were started by the North Carolina station until four years later, when a "strictly scientific station, not a model farm," to quote the language of Director Dabney, was established.

So much for the early setting of the agricultural experiment station.

The early distrust of field experiments, as voiced by Jordan, when at the New York station, Ledeaux and others was perhaps warranted. Attempts to draw conclusions from one or two years' work conducted on land that gave every evidence of a lack of uniformity, and without sufficient controls and replications, were very properly discredited.

At a later date—some 12 or 13 years ago—C. B. Lipman and Linhart, of California, gave perhaps the most severe criticism of field experiments made before or since. They concluded that "even when fertilizer experiments were properly planned and the results adequately studied by statistical methods, our present knowledge of the enormous variability of all soils and plants renders the data from any given fertilizer plot of value only on that plot, no matter how near the experimental one." And Lipman further concludes that such experiments are not worth "the large expenditure of money, time and energy involved."

In view of these and other criticisms of field plot work, the question arises, what is the attitude of present-day experiment station workers toward field plot experimentation? In order to secure definite information regarding this matter the following question was submitted to the agronomists of 15 representative experiment stations: "What has been the trend regarding field plot experimentation at your experiment station during the last 25 years? Has your station been increasing or decreasing this line of work in your state?"

These agronomists responded as follows:

From the Connecticut station: "There has been a marked increase in the amount of field plot work at this station during the last 25 years. In spite of the many weaknesses inherent in field plot work, still it can not be entirely dispensed with, and while our greenhouse and laboratory studies have also expanded we expect to continue field work."

From the North Carolina station: "During the past 25 years there has been a material increase in field plot experiments in this state."

From the California station: "In general our field plot work has increased quite materially during the past 25 years."

From the Kentucky station: "Twenty-five years ago this station had very little field plot work. At the present time we have in soil management, fertilizer and crops work approximately 2,900 plots. We do not have any sympathy with the idea prevailing in some quarters that field work has little or no value."

From the Michigan station: "The number of field plot experiments has greatly increased in recent years. We are very much interested in greenhouse experiments and laboratory studies. However to our mind the final test is the result given under actual field conditions."

From the Kansas station: "The general trend in this state at the present time is to increase the use of field plots in our soils experimental work. We believe that some types of work may be done successfully on very small areas and under greenhouse and laboratory conditions, but that field plots are also essential in many phases of our work."

From the Alabama station: "We have very definitely increased our experimental work using field plots as a means of securing more or less practical answers to more or less practical questions. It is our opinion that there is no other way to secure answers to many of our most important questions except through the use of field plots."

From the Minnesota station: "Minnesota has greatly increased the plot work with soils and crops out in the state, both on the sub-stations and on fields leased by the university. On the university farm plot work has

been decreased as this soil represents only a very small part of the state."

From the Tennessee station: "We have quite materially increased our plot work in the last 25 years. I consider work of this kind very important; in fact I would not know how to get along without it."

From the Wisconsin station: "Our faith in the value of the field plot as a medium of experimentation is increasing rather than decreasing. The trend, however, is more and more in the direction of a combination of field, greenhouse and laboratory work."

From the New York station (Ithaca): "The soil at Ithaca lacks uniformity to a rather unusual degree. This difficulty has led us to substitute what we call 'frames' for ordinary field plots. We also use the greenhouse for certain experiments, but I think that the extent to which a greenhouse may be substituted for field experiments is rather limited. We have not curtailed in any way the work on our outlying experiment fields."

From the Illinois station: "The trend in plot experimentation was distinctly upward until the cost of operation began to be almost unbearable. We had our peak in the number of crops and soils fields in 1919—forty fields. I suspect the number will be smaller than it has been in the past. We are emphasizing our laboratory research more than used to be the case. We must find a good balance between the two."

From the Indiana station: "During the last 25 years the field plot experimental work of this station has increased many fold. All our experience tends to strengthen the view that the results of carefully conducted and long-continued experiments on a reasonably representative field of any distinct type of soil will apply to other areas of the same type wherever found under similar climatic conditions. We hope to add to our permanent experimental fields until we have one on every important soil type in the state."

From the Iowa station: "The area on which we are now carrying experiments is five or six times as large as formerly. Too much emphasis can not be put on the value of field plot experimental work in soils and crops."

From the Pennsylvania station: "There has been a continued increase in our field plot experiments year by year up to the present time."

Such is the testimony of representative agronomists of the United States.

The greater use which is apparently being made of field plots in the solution of soils and crops problems, as indicated above, is probably in large part due to improved methods in field experimentation. With more replications and controls, with a greater appreciation of the possibility of experimental error and a technique adapted to the measurement of such error, results are being secured to-day that were not to be had in some of the earlier work.

Not only have methods been improved in field plot experimentation, but there has been a general refinement in methods along all lines.

It is not so long ago that our workers with animals were content to use from one to five animals in feeding tests and to draw conclusions therefrom regarding rations and gains. Now, from 20 to 100 animals on each ration are regarded as quite essential, and the work must be repeated several times. Numbers, replications and controls are exceedingly important.

There is, I think, a rapidly growing tendency to break down departmental lines in research institutions in joint attacks upon research problems, both in planning and carrying them forward. Much more valuable results are to be had from such cooperation. And similar cooperative attacks may be and are being carried on between different experiment stations and between state stations and the Federal department of agriculture.

While many of our experiment stations got under way without any help from the Federal Government, the Hatch Act of 1887, the Adams Act of 1906 and the Purnell Act of 1925 have proved a great stimulus to research work. In the expenditure of Adams funds a higher type of research was insisted upon.

Some 7 per cent. of the projects of the agricultural experiment stations of the United States is listed by the Office of Experiment Stations as Adams projects, and 12 per cent. as Purnell projects. The latter act especially encouraged research in agricultural economics, home economics and rural sociology. Approximately one half of the projects supported by Purnell funds are in these three lines of work.

The field of the agricultural experiment station is an ever broadening one. Beginning largely in an effort to protect the agricultural public from fraudulent practices in the manufacture and sale of commercial fertilizers, feed stuffs, seeds, etc., the experiment station has taken over the vast fields of soils and crops, animal production, dairying, horticulture, forestry, agricultural and biological chemistry, plant and animal nutrition, plant and animal pathology, economic entomology, bacteriology, genetics, agricultural economics, agricultural engineering, home economics, food technology, rural sociology, textiles and clothing.

As one looks backward over these 50 years of experiment station work, he is impressed with the contribution the stations have made to our material progress—the hundreds of new varieties of farm and horticultural crops which have been developed;

The many new legumes which have been discovered and introduced, some of which will be found adapted to our widely varying conditions;

The discovery and development of economic methods for combatting insects and diseases which have made relatively certain the production of crops and animals which was previously a gamble;

The improved methods of breeding and feeding all kinds of live stock for increased production in milk, meat and eggs;

The economic use of commercial plant foods and soil amendments;

The invention of the Babcock test and its consequent influence on all dairy practices—not to mention other contributions.

Up to 10 or 12 years ago it was the fashion to descant upon the grave dangers confronting this country and the world at large from our rapidly growing population overtaking our production of food and fabric materials. We hear none of this to-day.

But back of and leading up to these practical results are more permanent contributions to our fundamental knowledge which will bear fruit in the decades to come, for our experiment stations have not been content with knowing "what," but have pressed on to the "how" and the "why."

What of the future?

The financial situation in which many of our experiment stations now find themselves is discouraging. A reduction of state appropriations is very general. What course Federal appropriations will take is uncertain at this writing, but in spite of our tremendous financial depression it is hardly conceivable that the Federal Government will scrap an organization which it has been slowly building up for the last 40 years.

A reasonable support of these institutions would seem to be assured.

QUANTUM MECHANICS AND CHEMISTRY WITH PARTICULAR REFERENCE TO REACTIONS INVOLVING CONJUGATE DOUBLE BONDS[1]

By Dr. HENRY EYRING

FRICK CHEMICAL LABORATORY, PRINCETON UNIVERSITY

THE universally accepted conception of atoms as positive nuclei surrounded by electrons make it obvious that some sort of mechanics of such particles will properly describe their chemical behavior. The success of quantum mechanics in atomic physics where it gives quantitative agreement with experiment shows us clearly enough the general means to be employed. From this point of view it is convenient to regard the Schrodinger equation as our point of departure. Among the solutions of the Schrodinger equation which satisfy the supplementary quantum conditions only those which in addition obey the Pauli principle, *i.e.*, only those solutions which change sign when two identical particles are interchanged need be considered as having physical reality. Our scheme, though complete, is still much too difficult to proceed with. We must find other simplifying conditions. The first simplification is a familiar one. Because of the much greater mass of atoms than electrons the atoms travel relatively much more slowly so that in calculating the potential energy of any system from the Schrodinger equation we neglect the motion of the atoms without introducing serious error. The result is that we obtain a potential energy for the system under consideration as a function of the distance between the atoms, and this, as we shall soon see, provides just the necessary information for estimating rates of reactions. London was the first to point out that such a scheme probably provided a way for calculating activation energies. We next consider the nature of an activation energy. Consider the reaction $H_2 + I_2 = 2HI$. This is a well-known bimolecular reaction. For the rate of formation of HI, we can write

$$\frac{d(HI)}{dt} = f\,S\,e^{-E/RT}\,(H_2)\,(I_2).$$

The parenthesis around a formula indicates the concentration of that substance. Thus $S\,(H_2)\,(I_2)$ is the number of collisions between molecules of hydrogen and iodine in concentration units and can be calculated from kinetic theory, while the expression $e^{-E/RT}$ is the chance that in a particular collision the two molecules collide with an energy E in a form to permit reaction. The energy E is called the activation energy and has for this reaction a value of 40,000 calories. The precision of activation energy measurements is seldom better than one large calorie; so that activation energies are ordinarily specified in large calories. The proper fraction f in our rate expression approaches one for most simple reactions.

[1] Based on a paper presented before the Section of Chemistry of the American Association for the Advancement of Science at its Atlantic City meeting for which the anunal prize of the association was awarded.

It is a steric factor which measures the probability of a collision being of a kind to permit reaction even though it is sufficiently energetic. The variations in f for different reactions is of a different order of magnitude than the variation in $e^{-E/RT}$ so that by far the most important quantity in determining rates of reactions is the activation energy. Similar considerations hold for other types of reactions, so that if we can calculate the activation energy for the different mechanisms we are able to answer the very interesting question as to which way the reaction will proceed. For example, the reaction just considered might proceed by the alternative mechanism,

$$I_2 = 2I$$
$$I + H_2 = HI + H$$
$$H + I_2 = HI + I.$$

But both theory and experiment agree in preferring the mechanism $H_2 + I_2 = 2HI$, while for the reaction of the other halogens with hydrogen, as well as in the conversion of ortho to para hydrogen, they again agree in indicating reaction by way of the atoms. In the border line case of the reaction of hydrogen with bromine, obtaining the correct results depends somewhat on the assumed ratio of coulombic to interchange binding. The other cases give results so clear cut as to be independent of assumed ratios of interchange to coulombic binding. The fact that the calculations indicate that fluorine should not react with hydrogen at room temperatures seems to have attracted considerable attention, probably because of the early erroneous experiments widely quoted in the literature. Experiments of von Wartenburg, as well as some unpublished experimental results of Kassel and the author, leave no question of the chemical inertness of the mixture in diffuse daylight at ordinary temperatures. As a matter of fact, the contrary result would be startling when one considers the strong homopolar bonds to be broken. There is certainly a correlation between increase in the strength of the bonds to be broken and increase in the activation energy of a reaction. This was noted experimentally and follows as a matter of course from our theoretical calculations.

Before proceeding further with a discussion of our results it is perhaps well to consider in a little more detail the method of calculation. The coulombic portion of the energy of a homopolar bond between a pair of atoms increases from 10 per cent. in the case of non-metals like hydrogen to 28 per cent. in the case of metals like sodium and is independent of the presence of other atoms. That is to say, the attractive potential just adds up for all atom pairs, no matter how many atoms are in the neighborhood of a given atom. The remaining part of the bonds, called the interchange binding, add up quite differently. The laws of addition up to and including eight electrons are now known as a result of investigations in this and other research centers and the indefinite extension to larger numbers of atoms only awaits a real need. The extension offers no more difficulty than that of being very tedious. The evaluation of the coulombic and interchange binding between atom pairs as a function of the distance between the atoms is accomplished by reference to curves constructed from spectroscopic constants. Empirical Morse curves are at present the most convenient for this purpose. Knowing the amounts of interchange and coulombic binding and the laws of addition it is then a simple matter to calculate the energy of any configuration, and so construct a surface which enables us to follow the mechanism of approach of two molecules until they reach a point where new bonds are as strong as old ones and we find a new pairing of the atoms taking place. Such potential surfaces in the simple cases involving three atoms consist of two long valleys corresponding to configurations of the initial and final substances separated by a saddle over which the system must pass. The height of this saddle measured from the initial valley floor is the activation energy for the forward reaction. For the reverse reaction the activation energy is measured from the floor of the other valley. The heat of reaction is of course the difference in the heights of the valley floors. In case of a reaction such as the unimolecular decomposition of N_2O the initial region is a basin instead of a valley separated as before by a saddle from the final valley or valleys. The study of the kinetics of this reaction simply involves the study of a mass point on such a surface. Because of a change in multiplicity in the decomposition of N_2O the reaction surface is a composite of two intersecting surfaces and some attention must be given to transition at the junction. With molecules containing more atoms, more dimensions are required for our surface, but the essential problem of finding the height of a saddle value measured from a valley or basin remains. In my first paper, with Professor Polanyi, these methods applied to the reaction between a hydrogen atom and a hydrogen molecule gave results in good agreement with the experimental activation energy found by A. Farkas.

Pelzer and Wigner, then, carrying the matter further, were able to show that the rates calculated, entirely theoretically, were in very good agreement with experiment; so that apparently in the reaction of a hydrogen atom with a hydrogen molecule we have for the first term a rather satisfactory detailed picture of a reaction.

In cooperation with Mr. A. Sherman these methods were then applied to the reaction in which the con-

version of ortho to para hydrogen takes place on a surface. Again, so far as we can now judge, we find agreement with experiment. The process seems to be one in which a hydrogen molecule is split into atoms by two surface carbon atoms which are abnormally far apart, each hydrogen atom becoming attached to a surface atom. These hydrogen atoms are now apt to leave the surface with a different but similarly situated hydrogen atom by the reverse of the absorption process. The conversion is thus completed. The result that for the greatest ease of activated adsorption the carbon atoms should be from four to five times as far apart as the normal distance between the hydrogen atoms is a rather striking part of this picture. This would be achieved in lattices in which some positions are vacant and we should therefore expect the instability to heat treatment customarily found with very active surfaces. Since a particular distance of surface atoms favors adsorption of a particular type of molecule, preferential adsorption is to be expected. These calculations indicate that the conception sometimes held, that an equal distance between surface atoms and the atoms in the gaseous molecule favors activated adsorption, should be abandoned.

With Dr. Kimball an examination was made of the proposed mechanism for the hydrogen chlorine reaction

$$Cl + H_2 + Cl_2 = 2HCl + Cl.$$

The calculations indicated it to be far slower than the reaction

$$Cl + H_2 = HCl + H$$

and so the first reaction could be excluded. This seems to be in keeping with the most recent experimental opinion. Similar although rougher calculations indicated that water should not be helpful in this reaction which apparently contradicted experimental findings at the time but is apparently at present in agreement with experimental findings.

In a paper appearing this month in the *Proceedings* of the National Academy it is pointed out that the difference in zero point energy for compounds of two isotopes makes the lighter isotope more reactive, and so should assist in their separation. Whether or not this is the principal factor in enabling Dr. E. W. Washburn to preferentially electrolyze away the lighter isotope from water remains to be seen.

We thus bring to a new problem a considerable confidence in the essential correctness of our method. It was with this background that we considered the additions of hydrogen and bromine to butadiene. The details of the calculations together with certain extensions will be published elsewhere as a joint paper with Mr. Albert Sherman and Dr. George E. Kimball. The addition of bromine may be expected to occur in either of two ways:

$$Br_2 + H_2C = CH - CH = CH_2 \rightarrow BrH_2C - CH = CH - CH_2Br$$
$$\rightarrow BrH_2C - CHBr - CH = CH_2.$$

Taking explicitly into account in both cases the six electrons which change partners in the first reaction and using simply the methods already outlined we find for the first reaction an activation energy of 36.4 kilo calories, for the second an activation energy of 52 kilo calories. It thus seems sufficiently clear why 1–4 addition is to be expected. The sort of thing which might cause 1–2 addition to be preferred of course is to substitute for a hydrogen on 4 some group that introduces large steric effects. We hope to return to this aspect of the problem in the not too distant future. If the same calculations are made for the substitution of hydrogen to butadiene the activation energy for 1–4 addition is found to be 77 kilo calories and for 1–2, 113. Emphasis is of course not to be placed on the exact value of our figures, but their relative correctness seems reliable. The size of the calculated activation energies indicates, certainly in the case of hydrogen, that any addition can only occur catalytically. In the case of the addition of bromine the indication is less clear cut that the reaction must go by way of surfaces, but it certainly should be examined from that point of view. The factors which favor 1–4 addition in the gas phase will of course be less important for catalyzed reactions.

The significant point again seems to be at least qualitative agreement between theory and experiment. Very much remains to be done in the way of examining more closely the underlying approximations of this method with the idea of obtaining more precise results; but apparently even in its present unfinished form we have a surprisingly powerful tool with which to attack the almost endless variety of problems of chemical mechanism. Something is also gained by having a scheme into which the multitudinous experimental results may be fitted.

OBITUARY

DR. WILLIAM ARNON HENRY

DR. WILLIAM ARNON HENRY, one of the outstanding pioneers in the development of agricultural instruction, research and extension in this country, died at his home in San Diego, California, on November 24, 1932, from an attack of pneumonia.

The life story of Dean Henry, as he was usually called, is one to inspire youth and is typically Ameri-

can. Born on a farm near Norwalk, Ohio, on June 16, 1850, he was still in his early teens when his father was called into the Union army. Heavy responsibilities then fell upon the boy, which undoubtedly aided much in developing the great capacity for work which later characterized him. After a period of study in Ohio Wesleyan University, he had to interrupt his course to earn money by teaching school. He then entered the course in agriculture at Cornell University and through supplementing the funds he had saved, by doing whatever work he could find, he completed his course in 1880 and received the B.S. degree.

Immediately after graduation he was selected to take the position of professor of botany and agriculture at the University of Wisconsin. The "and agriculture" part of his title meant little, for there was no agricultural college, no experiment station and not even a department of agriculture in the university. He was to take charge of the university farm, which was badly run down, and to endeavor to develop the agricultural work so it would serve the farmers of the state.

Henry's career furnishes an outstanding example of a man whose far-sighted vision and keen judgment led him to make a radical change from his first specialty. Though trained as a botanist and horticulturist, when he became acquainted with Wisconsin conditions, he became convinced that live-stock farming and especially dairying offered the most general possibilities for success. He therefore threw his great energy into the development of dairying and other phases of the live-stock industry. Not only was his work one of the important factors in the development which made Wisconsin the leading dairy state, but also he gained an international reputation as an authority on live-stock feeding. He was granted honorary doctor's degrees by the University of Illinois, the University of Vermont and Michigan Agricultural College in recognition of his accomplishments and his services to agriculture.

At first Henry had practically no funds for research and indeed all facilities were most meager. With his magnetic personality, he soon interested some of the legislators in his work and secured a modest appropriation for investigations on the ensilage of fodders and the manufacture of cane-sugar from sorghum cane. This is of especial interest because it was the first definite state appropriation for research at the university. Henry later delighted in telling how one of the legislative leaders leaned across the aisle when the appropriation was under discussion, and remarked to his boon companion, "Let's kill this pup before it gets to be a dog." Only because of Henry's inspirational zeal and enthusiasm was he able to convince the legislators that it was wise public policy for the state to support agricultural investigations.

The investigations begun under this appropriation were instrumental in convincing farmers of the value of silage in live-stock feeding and resulted in there being more silos in Wisconsin than in any other state. Not only did he develop the agricultural work at the university, but also he literally "stumped the state," preaching scientific agriculture to the farmers on every possibility and winning them by his personality and clearly stated facts. Undoubtedly it was Henry who first "sold" the agricultural college and the university as well to the people of the state. He focused attention on the possibilities of the university as a service agency for the whole citizenry, using every means at his command—lectures, bulletins, press articles and interviews.

In these early days very few students were enrolled in the regular university courses in agriculture. Therefore, in an endeavor to interest farm boys in agricultural instruction, there was begun in 1885 under Henry's direction the first agricultural short course in America. The idea of giving at a university practical instruction to students who were not graduates of a secondary school met with ridicule and scorn on the part of many educators, but the short course was exceedingly successful and a somewhat similar plan has been adopted in practically every state.

He saw at an early date that an accurate and simple test for the butter fat in milk was urgently needed by the dairy industry, and stimulated the late Dr. S. M. Babcock to undertake the investigations which led to the invention of the well-known Babcock test in 1890. The same year he started the first dairy course in America in which practical instruction was given in the testing and manufacture of dairy products.

Burdened with numerous and exacting administrative and teaching duties, nevertheless he found time for research on many problems in animal production which were both of practical and scientific importance. He was among the earliest to study the effect upon the growth and development of farm animals of rations ample and deficient in protein and in minerals; the value of silage for live stock; the effect of various methods of preparing feeds for swine, and the value and use of dairy by-products in stock feeding. In his writings and addresses he continually emphasized the importance of efficiency in farming and he was a firm advocate of cooperative effort among farmers. As an author, Henry's lasting fame rests on "Feeds and Feeding," which for thirty-four years has been the most widely used text and reference work on live-stock feeding in the English language and is now in the 19th edition.

Energetic to the extreme, he never spared himself, but gave every ounce of his strength to the upbuilding of the agriculture of his state. Due primarily to this, his health at last broke under the strain, and in 1907 he retired from his university duties.

Few know that Henry was to a considerable degree responsible for the passage of the parcel post bill in 1912. Convinced of the value of parcel post to farmers, Henry worked for months in advocating the legislation. Appreciating the value of concerted action, he wrote to the agricultural editors of the country and asked them to announce a "Parcel Post Day" on March 1, 1912. On this day, all who were in favor of parcel post were asked to write their congressmen personal letters. As a result, the lawmakers at Washington were fairly deluged with a mountain of mail from all the rural districts.

After his retirement Henry spent considerable time in Connecticut, developing a large fruit farm with his only son, Arnon T. Henry. Later he took much pleasure in collecting rare plants for his residence on the west coast of Florida, and for the last several years resided in San Diego, where he indulged his early interest in horticulture and botany.

FRANK B. MORRISON
CORNELL UNIVERSITY

RECENT DEATHS

EUGENE E. HASKELL, consulting hydraulic engineer, dean of the College of Civil Engineering at Cornell University from 1906 to 1921, when he retired with the title of professor emeritus, died on January 28, at the age of seventy-seven years.

PROFESSOR WILLIAM LISPENARD ROBB, head of the department of electrical engineering at Rensselaer Polytechnic Institute since 1902, died on January 26, at the age of seventy-one years.

DR. WILLIAM PHILLIPS GRAVES, professor of gynecology at Harvard Medical School since 1911, died on January 25, at the age of sixty-three years.

DR. VICTOR STERKI, assistant curator of zoology in the Carnegie Museum, Pittsburgh, died on January 25, at the age of eighty-six years. The Sterki collection of mollusca will be deposited in the museum.

SIR WILLIAM TAYLOR, president of the Royal Academy of Medicine in Ireland since 1927, died suddenly on January 29, at the age of seventy-two years. He was an honorary fellow of the American College of Surgeons and a past president of the Association of Surgeons of Great Britain and Ireland.

DR. MALCOLM EVAN MACGREGOR, in charge of the Wellcome Entomological Field Laboratories at Esher, Surrey, died on January 12, at the age of forty-three years.

PROFESSOR GUIDO TIZZONI, until four years ago professor of general pathology at the University of Bologna, has died.

THE death is announced of Dr. Albert Wigand, professor of meteorology at Freiburg, and of Dr. Karl Kreibich, professor of dermatology at the German University at Prague.

DR. HEINRICH MAHNKOPF died on December 20, 1932, aged forty years. He was a chief of division at the Prussian Geodetic Institute in Potsdam and Dozent at the Technische Hochschule in Berlin. Volume VI of the Publications of the International Latitude Service was recently completed and published under his direction. He succeeded Albrecht and Wanach in the work of the Latitude Service.

A CORRESPONDENT writes: "Miss Julia Irene Goodrich, known to many hundreds of biologists through the assistance she gave them in getting settled on their first arrival at Cold Spring Harbor, died January 21, at the age of fifty-seven years. Miss Goodrich was for twenty-seven years secretary to the director of what is now the department of genetics. She graduated from Smith College, showing especial proficiency in the classics and languages in general, like her uncle Chauncey Goodrich, who compiled a Chinese dictionary and translated the Bible into Chinese, and his son, L. C. Goodrich, lecturer in Chinese at Columbia University. Another uncle was professor of Latin at the University of Vermont. She was a member of the American Association for the Advancement of Science."

SCIENTIFIC EVENTS

CONFERENCE ON SPECTROSCOPY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE Massachusetts Institute of Technology announces a Summer Conference in Spectroscopy in connection with its new Spectroscopy Laboratory. The arrangements are in charge of Professor George R. Harrison, and it is hoped that such a conference may become an annual summer event. On account of the air conditioning of the laboratory and the availability of summer cottages within commuting distance on the shore, this conference makes possible a combination of summer vacation with interesting scientific work under comfortable conditions.

The research facilities embrace five general subjects (1) quantitative measurement of spectrum in-

tensities, (2) measurement of hyperfine structure, (3) analysis of spectrum series, especially with the aid of the newly developed mechanical analyzer, (4) vacuum spectroscopy of the ultra-violet, (5) quantitative chemical analysis by spectroscopic methods. In all these fields the laboratory possesses unexcelled, and in the second and fourth fields, unique, facilities. In addition to opportunities for conference and research, there will be graduate courses in spectroscopy, atomic and molecular structure and related subjects.

The plans provide for three groups: (1) scientists of recognized achievements in the field of spectroscopy, who will be guests of the laboratory, (2) graduate students who will be expected to pay moderate tuition fees, (3) industrial organizations which may send qualified representatives to work on spectroscopic problems of chemical analysis, or which may submit problems to be worked on by industrial research fellows under supervision of the laboratory staff, in accordance with contracts to be made with the Institute's Division of Industrial Cooperation.

Requests for information in regard to facilities or summer living arrangements and applications for admission to these activities should be addressed to Professor George R. Harrison, Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts.

THE FIFTH UNIVERSITY OF MICHIGAN GREENLAND EXPEDITION

THE Fifth University of Michigan Greenland Expedition is included among the Second Polar Year Expeditions of 1932–33. This expedition is directed by Professor Ralph L. Belknap, who was second-in-command on earlier Michigan expeditions. With Evans S. Schmeling, aerologist, and Herbert Gardner, photographer and botanist, he sailed for Greenland on the *Morrissey,* Captain Robert A. Bartlett, master, which took the Peary Memorial Expedition to North Greenland last summer. His companions were landed with the supplies of the expedition on the neck of the Upper Nugssuak Peninsula in latitude 74°, while Dr. Belknap proceeded to Cape York to act as construction engineer in the erection of the Peary Shaft.

The expedition base is much the same as that of the Cornell Expedition more than thirty years ago and the station is located near the front of the Cornell Glacier outlet. Dr. Belknap, the director, rejoined his expedition on August 31 and the lumber used in erection of the Peary Shaft was then used to build the hut of the expedition, which has been named Peary Lodge. On September 18, Max Demorest, assistant aerologist, and Hansen, radio operator, with additional supplies, arrived from Upernivik on the little motor sloop *Saelen.* The *Saelen,* carrying letters on its return, was wrecked with the loss of all on board, so that relatively meager reports from Dr. Belknap have been received up to the present. However, a number of radio messages, relayed through various amateur stations, have indicated that the party is well, and that scientific work, particularly that in aerology, has been proceeding satisfactorily. The winter night, which arrived in early November, has since that time interfered with the upper-air studies.

When in February or March the light becomes better Dr. Belknap plans to make a somewhat extended penetration by dog sled of the inland ice and carry out various scientific studies including the upper air and sounding of the glacier. The expedition is expected to return in early October.

WILLIAM H. HOBBS

THE FIFTH PACIFIC SCIENCE CONGRESS

ANNOUNCEMENT has been made recently by the National Research Council of Canada that plans have been resumed for holding in the coming summer the Fifth Pacific Science Congress, which it had been originally planned to hold last May. This congress will convene in Victoria and Vancouver, British Columbia, between the dates June 1 and 14, 1933. During the week following the sessions of the congress, excursions will be conducted through the western part of Canada.

The purpose of this series of congresses is to give opportunity for the discussion of scientific problems relating to the Pacific area, and to plan for the advancement of research upon these problems through the coordinated efforts of research institutions in the countries within the Pacific region. Previous congresses were held in Honolulu (1920), Sydney and Melbourne (1923), Tokyo (1926), and Batavia and Buitenzorg (1929). The congresses are organized under the immediate auspices of the National Research Council or corresponding scientific body in the country in which they are held, and are under the general sponsorship of the Pacific Science Association, which comprises scientific organizations from fourteen of the Pacific countries.

The program of the congress this year will include a series of general symposia upon the recent applications of science in forestry, agriculture and fisheries, also a general symposium upon the geological significance of the fiords in lands bordering on the Pacific Ocean, and a symposium for a discussion of the origin and antiquity of the American aborigines. Other sessions of the congress will be arranged in two general groups, one for the biological sciences and one for the physical sciences. In the former, provision will be made for the discussion of problems relating to agriculture, anthropology and ethnology, animal diseases, public health, botany and plant pathology, forestry, zoology, entomology and fisheries.

In the group for the physical sciences provision will be made for the discussion of problems of astronomy, geodesy and geography, geology and mineral resources, seismology and volcanology, oceanography, meteorology and terrestrial magnetism, and radio communications. The contributions to the program of the congress will consist mainly of specially invited papers.

The Government of the United States has been invited by His Majesty's Government in Canada to participate in this congress by the appointment of twenty-five official delegates to the congress from this country. These delegates will be named by the government. In addition the National Research Council of the United States has been authorized to extend an invitation to the learned organizations and institutions in this country to participate in the congress. Universities, societies and research institutions which may wish to appoint representatives to attend this congress are requested to communicate with the National Research Council.

W. H. HOWELL,
Chairman, National Research Council

ENGINEERING WEEK AT CHICAGO

PLANS for the conference of engineers at Chicago, during Engineering Week, June 25 to 30, which is being sponsored by the Century of Progress Exposition, are making progress. Education will be an important theme of the conference, with the Society for the Promotion of Engineering Education taking an important part. In addition to its sessions some twenty of the national engineering societies will participate with sectional and national meetings.

On Sunday evening, June 25, when Engineering Week opens officially, the International Union of Pure and Applied Physics will have a joint session with Section M of the American Association for the Advancement of Science. A number of the engineering societies will participate with a program which is being arranged on the "Application of Physics to Engineering" by Dr. R. A. Millikan. On the evening of June 27, A. P. M. Fleming and H. Gough, of England, will address a similar joint session on "The Industrial Developments of the Century."

In addition to the individual activities of the various groups during the week, there will be a joint conference on Engineers Day. The program for this day includes a banquet at the Hotel Stevens. It is expected that there will be an attendance of more than 3,000. The program, which is not yet ready for announcement, will include addresses by distinguished American and foreign scientific men and engineers.

In addition to the educational exhibits at the Century of Progress Exposition, the sixth Midwest Engineering and Power Exposition will be held at the Coliseum during that week. At this exposition some 300 manufacturers will exhibit the latest developments in steam-generating equipment for power and process purposes. In addition there will be a wide range of equipment such as heating and air conditioning apparatus, water treatment and softeners for swimming pools and many other items of interest to engineers and superintendents of schools.

AWARD OF THE NICHOLS MEDAL

AWARD of the William H. Nichols Medal of the New York Section of the American Chemical Society for 1933 to Dr. Wilder D. Bancroft, professor of physical chemistry at Cornell University, has been announced by Dr. Walter S. Landis, chairman of the Medal Committee. The medal will be presented at a meeting of the New York Section in the Electrical Institute Auditorium, Grand Central Palace, on March 10. "Protein Therapy" will be the subject of Professor Bancroft's medal address. Other speakers will be Professor W. Lash Miller, of the University of Toronto, who will narrate the achievements of Professor Bancroft, and Dr. Charles L. Parsons, of Washington, D. C., secretary of the American Chemical Society, who will discuss the personal aspects of Professor Bancroft's career. Dr. Victor K. LaMer, professor of chemistry in Columbia University and chairman of the New York Section, will preside.

In announcing the award Professor Bancroft's work is described as follows:

Professor Bancroft's researches are derived from the work of Claude Bernard, French physiologist who sixty years ago advanced the view that anesthesia was due to a reversible coagulation of some of the proteins of the brain and of the sensory nerves. Although biologists, physiologists and medical men rejected Bernard's view, Professor Bancroft has demonstrated that it is of "enormous importance in physiology, pharmacology and medicine."

Professor Bancroft's general conclusions are that in some forms of insanity a coagulation of brain and nerve protein occurs. In others, protein dispersion takes place. He points out that in manic depression and epilepsy a slight coagulation of protein has taken place in either all or a part of the brain. Therefore, he concludes that a chemical agent which has the opposite effect on proteins should work toward a cure.

Through the use of these methods, Professor Bancroft's researches have indicated that the use of sodium rhodanate may cure narcotic addiction and that it may also be employed eventually as a treatment for hay fever.

"If the brain is permanently abnormal," according to Professor Bancroft, "the thinking will be abnormal also and the patient will be called insane. The brain can be abnormal in two ways, by being too puckered or by being too mushy. There must therefore be two types

of insanity, a puckered type which will be helped by sodium rhodanate and a mushy type which will be helped by an anesthetic such as sodium amytal. These two types exist and can be helped in this way. Manic depressives and epileptics are of the puckered type; dementia praecox catatonics are of the mushy type."

SCIENTIFIC NOTES AND NEWS

DR. ALBERT EINSTEIN, who sails for Europe on March 15, will be the guest of honor at a dinner, given by friends of the Hebrew University in Jerusalem, at the Hotel Commodore, New York City. It is expected that a thousand men of science and letters will attend. It is planned to present to Dr. Einstein at the dinner a fund for the Hebrew University and for other organizations in which he is interested. The fund, it is hoped, will reach $100,000.

THE Edison Medal for 1932, awarded to Bancroft Gherardi, vice-president and chief engineer of the American Telephone and Telegraph Company, in recognition of his "contributions to the art of telephone engineering and the development of electrical communication," was presented to him by the president, H. P. Charlesworth, at the recent annual convention in New York City of the American Institute of Electrical Engineers. The principal speakers were Dr. Gano Dunn, of New York City, and Dr. Dugald C. Jackson, head of the electrical department of engineering of the Massachusetts Institute of Technology and chairman of the Edison Medal committee.

THE presentation of the Alfred Noble Prize to Frank M. Starr, of the General Electric Company, was made on January 23 at the opening meeting of the American Society of Civil Engineers. The prize, an award of $500, was presented by Arthur S. Tuttle, vice-president of the American Society of Civil Engineers, which is trustee for the memorial fund created in 1929 by friends of Mr. Noble. The award was made for a published paper, "Equivalent Circuits—II."

DR. WILLIAM BOWIE, of the U. S. Coast and Geodetic Survey, has been awarded, by the Royal Academy of Belgium, the Charles Lagrange Prize in recognition of his having effected the complete unification of the triangulation systems of Canada, the United States and Mexico. North America is the only continent having a single triangulation system.

MERLE RANDALL, professor of chemistry at the University of California, has been awarded a medal of merit by Charles University of Prague, in recognition of his contributions in research and the training of young men for careers in chemistry.

DR. GLADYS A. REICHARD, Barnard College, Columbia University, has been awarded the A. Cressy Morrison Prize by the New York Academy of Science for her monograph entitled "Melanesian Design: a Study of Style in Wood and Tortoise Shell Carving."

DR. EMIL ABDERHALDEN, professor of physiology at Halle, has been elected an honorary member of the Italian Society for Experimental Biology.

F. E. MATTHES, of the United States Geological Survey, has been elected president for 1933 of the Association of American Geographers, and S. S. Visher, of Indiana University, vice-president. The secretary, F. E. Williams, of the University of Pennsylvania, and the treasurer, R. S. Platt, of the University of Chicago, were reelected.

PROFESSOR GEORGE C. HUMPHREY, of the University of Wisconsin College of Agriculture, was recently elected president of the American Society of Animal Production.

AT the annual general meeting in London of the Royal Meteorological Society on January 18, Professor S. Chapman was reelected president. The Buchan Prize, awarded biennially for the most important original papers contributed to the society during the previous five years, was presented to D. Brunt.

DR. HARRY WOODBURN CHASE, president of the University of Illinois, previously professor of psychology and president of the University of North Carolina, has been elected chancellor of New York University to succeed Dr. Elmer Ellsworth Brown.

DR. WALTER H. EVANS, chief of the Division of Insular Stations of the Office of Experiment Stations, U. S. Department of Agriculture, reached the compulsory retirement age on February 1. During his forty-one years' service in the department, first as botanist and botanical editor of the *Experiment Station Record*, then as chief of the Division of Insular Stations of the Office of Experiment Stations, and for a time as acting chief of the office, Dr. Evans was responsible for establishing and developing agricultural experiment stations in Alaska, Hawaii, Puerto Rico, Guam and the Virgin Islands, and in promoting research, particularly in plant physiology and pathology, by the state experiment stations.

DR. CHARLES WEISS, formerly associate professor of applied bacteriology and immunology at Washington University School of Medicine, has been appointed director of the Clinical and Research Laboratories of the Mount Zion Hospital, San Francisco, California. He has also been appointed associate professor of research medicine in the Hooper Foundation of the University of California, and consulting immunologist to the University of California Hospital.

PROFESSOR W. S. NELMS, of the department of physics of Emory University, has been granted leave of absence for the coming spring quarter. He will spend the time at the University of Cambridge and the University of Berlin.

OTTO DEGENER, who is writing a comprehensive illustrated Flora of the Hawaiian Islands, has shipped a large collection of herbarium specimens to New York preparatory to its critical study at the New York Botanical Garden. This collection is the result of extensive botanizing on all the major islands of the Hawaiian Archipelago during the last ten years.

DR. J. DUFRENOY, director of the Station for Plant Pathology, near Bordeaux, is spending six months at Riverside, California, in the laboratory of plant physiology at the Citrus Experiment Station, investigating the cytological conditions associated with mottle leaf of citrus and other trees. He has been granted a fellowship by the Rockefeller Foundation for this investigation.

DR. OTTO HAHN, director of the Kaiser Wilhelm Institute of Chemistry at Dahlem and lecturer in chemistry (radioactivity) at the University of Berlin, will reach Ithaca in February, where he is this year non-resident Baker lecturer in chemistry. He will lecture for three months on his work on the chemistry of radium.

PROFESSOR J. J. R. MACLEOD, professor of physiology at the University of Aberdeen, and previously at the University of Toronto, is visiting professor at the Johns Hopkins University, where he is giving the Herter Lectures.

DR. ERNEST W. BROWN, professor of mathematics at Yale University, gave the second Arthur Lecture at the Smithsonian Institution on January 25. His subject was "Gravitation in the Solar System."

DR. HARVEY CUSHING, who last year retired as Moseley professor of surgery, Harvard University Medical School, delivered the fourth Harvey Lecture at the New York Academy of Medicine on January 19, on "Dyspituitarism: Twenty Years Later."

DR. IRVING LANGMUIR, of the General Electric Company, lectured on the adsorption theory at the Charlottenburg Institute of Technology on January 27. He was introduced by Professor Walther Nernst, with whom he was formerly a student.

CAPTAIN SIR HUBERT WILKINS, explorer of the Arctic and Antarctic, will lecture in the James Simpson Theater of the Field Museum, Chicago, at 3 P. M. on March 4. His subject will be "What I Have Discovered in the Arctic and Antarctic." He will relate his experiences on expeditions made by dog team, by airplane and by submarine. The lecture will be illustrated with motion pictures.

DR. F. G. DONNAN, professor of inorganic and physical chemistry at University College, London, gave the Ostwald Memorial Lecture of the British Chemical Society at the University of Liverpool on January 27.

PROFESSOR S. L. BOOTHROYD, of Cornell University, lectured at Lehigh University on January 11 under the auspices of Lehigh Chapter of Sigma Xi on "Meteors or Shooting Stars," describing some aspects of the work of the Harvard-Cornell Meteor Expedition to Flagstaff, Arizona.

THE Sigma Xi Club of the University of Florida held its annual banquet on January 18. Mr. H. H. Hume, director of the University Experiment Station, spoke on "The University of Florida in its Relation to the State as a Research Institution." He outlined many of the problems which are awaiting study and emphasized the university as constituting a disinterested agency for investigating these problems.

THE Sigma Xi Club of Montana State College held a public meeting on January 26, at which Dr. O. E. Sheppard, head of the department of chemistry, delivered a lecture concerning "Recent Developments in Chemistry," with a detailed discussion on the physics and chemistry of color production. This lecture was one of a series of three public lectures on "The Frontiers of Science" being given under the auspices of the club.

DR. D. B. JUDD, of the section of colorimetry of the Bureau of Standards, delivered three lectures on color vision at Bryn Mawr College on January 16, 17 and 18. A fourth meeting was devoted to a demonstration which included the blue arc phenomenon, the Purkinje after-image and examples of color transformation.

DR. JOHN H. PARKER, professor of plant breeding at the Kansas State College, Manhattan, gave the fourth series of annual lectures under the Frank Azor Spragg Memorial Fund, from January 24 to 27, at the Michigan State College. This memorial is in honor of Professor F. A. Spragg, who was in charge of plant breeding work at the Michigan Agricultural Experiment Station from 1906 to 1924.

DR. GEORGE SARTON, current Hitchcock professor at the University of California, was speaker on January 15 at the first meeting of the Singer History of Science Club, organized as a result of Dr. Charles Singer's recent visit of a year to the university and composed of faculty members and students interested in the history of science and its promotion as a field of scholarship. Dr. Sarton's address was on Simon

Stevin, sixteenth and seventeenth century Dutch mathematician, the first advocate of the decimal system for common use.

MEETINGS of the American Chemical Society are planned as follows: Washington, D. C., week of March 26, 1933; Chicago, Ill., week of September 11, 1933; St. Petersburg, Fla., March, 1934; Cleveland, Ohio, autumn of 1934; Eleventh Colloid Symposium, Madison, Wis., June 15 to 17, 1933; Fifth National Organic Chemistry Symposium, Cornell University, Ithaca, N. Y., December 28 to 30, 1933.

THE American Society of Mammalogists will hold its fifteenth annual meeting at the new Biological Institute, Harvard University, from May 10 to 13. Titles of papers must be filed before April 28 with the corresponding secretary, Dr. Robert T. Hatt, the American Museum of Natural History, New York.

A UNION OF GERMAN BIOLOGISTS has recently been formed, with Professor Lehmann, of Tübingen, as president.

MRS. FRANCES KINSLEY HUTCHINSON has given an estate of seventy-three acres at Lake Geneva, including a house on the property, with an endowment, to the University of Chicago for botanical work.

COLUMBIA UNIVERSITY and the Metropolitan Museum of Art will ultimately share in a trust fund of $150,000, bequeathed by the late William Fitz Randolph, of Glenbrook, Connecticut. The gross estate is valued at $601,073. After smaller bequests are paid, the two institutions are named as the residuary legatees.

THE new Royal Society Mond Laboratory of the University of Cambridge was opened on February 3 by Stanley Baldwin, as chancellor, who accepted the building for the university. The principal speakers were Sir Ernest Rutherford and Sir Robert Mond. The laboratory is an adjunct of the Cavendish Laboratory and will be directed by Professor Peter Kapitza, of Russia. It is reported that it will provide facilities for research into the magnetic properties of matter in the highest fields yet attained and for the study of properties of matter at lowest possible temperatures. Last year, when the need for greater accommodations became urgent, the council of the Royal Society offered the university a fund to build and equip the new laboratory. At the same time, through reorganization, accommodation of the scientific departments was made possible by a Rockefeller gift, which freed a site near the Cavendish Laboratory for the new building.

WITH appropriate exercises on the afternoon of January 14, the new museum building of the San Diego Society of Natural History, Balboa Park, San Diego, California, was opened to the public. The same occasion marked the fifty-eighth annual meeting of the society, which is the oldest scientific organization in southern California. The building is of concrete construction, with a frontage 220 feet long, and a wing 100 feet deep, and forms the first unit of what may eventually be a much larger museum plant. Provision has been made in the present structure for exhibition halls on three floors, a lecture hall, children's museum, administrative offices, workrooms and laboratories for all departments. The building represents an investment of about $175,000, which was raised by public contributions, largest of which was the gift of $125,000 by the late Miss Ellen B. Scripps, of La Jolla. William Templeton Johnson, of San Diego, was the architect. For the past sixteen years the museum collections have been housed in temporary exposition structures in Balboa Park.

PURDUE UNIVERSITY announces the completion, during the summer of 1932, of new laboratories for plant physiology and plant pathology in the School of Science. These laboratories are built around greenhouse units. The physiology laboratories are three in number, including elementary, advanced and private research laboratories. The pathology laboratory is in addition to those already in use in plant pathology and provides space for elementary study with rooms adjoining for research. Basements extend under most of the construction and will be equipped for controlled light, temperature and humidity research. New advanced courses will be offered both in plant pathology and plant physiology.

WALTER MERRITT SEWARD, who died on December 20, 1932, at the age of seventy-two years, formerly practiced medicine in New York, but for the past twenty years had been looking after a country practice in Brunswick County, Virginia, mostly on a charity basis. He had also been managing his timber lands in that county. A correspondent writes: "At the time Dr. Seward attended the Medical School of the University of Virginia, class of 1886, that school lacked proper clinical and hospital equipment. The lack of clinical and hospital equipment has since been supplied to the School of Medicine. But for some years, indeed since its inception in 1910, the School of Forestry at the University of Virginia has lacked an experimental and practise forest, which in a general way corresponds to clinical and hospital equipment in medical instruction. Dr. Seward's will leaves his forest of more than three thousand acres and more than two hundred thousand dollars in securities to the University of Virginia for the benefit of the School of Forestry. His bequest supplies the needed experimental and practise forest and greatly strengthens and enlarges the usefulness of the School of Forestry."

THE sixth session of the Allegany School of Natural History, in Allegany State Park, New York, will be held from July 5 to August 24, under the auspices of the Buffalo Museum of Science. Founded under favorable natural conditions in suitable location and surroundings, the Allegany School of Natural History offers courses for studies in botany, zoology and geology with emphasis on natural history. An instructor is provided for each class a full day each week and for a conference hour later in the week. In addition each student works out of class independently or with occasional direction for nearly two days. The courses offered are field zoology and field botany, the natural history of birds and nature study. The small classes and the plan of the schedule make it possible for the faculty to continue actively in research. There is an open-air museum, a nature trail, an Indian garden, a water garden and a fernery. Elsewhere in the park are hiking trails, swimming pools, bridle paths, baseball diamonds, tennis courts and a 120-acre lake with boating.

DISCUSSION

THE NAMING OF THE SUBDIVISIONS OF THE WISCONSIN GLACIAL AGE

AT the 1930 meeting of the Geological Society of America, held in Toronto, the writer presented a paper on "The Peorian Loess and the Classification of the Glacial Drift-Sheets of the Mississippi Valley," which was subsequently printed in the *Journal of Geology*.[1] In this paper he called attention to the fact that the evidence that the Peorian (Iowan) loess had been weathered before the Early Wisconsin drift had been deposited was not valid; that the only evidence of an interval was that of rapid deposition of loess. Therefore, two important conclusions were drawn; (1) the Peorian interval was not of interglacial magnitude but was intraglacial; and (2) the Iowan ice invasion was the first of the Wisconsin invasions.

Additional confirmatory evidence was found during the 1931 field season, and another paper was presented at the 1931 meeting of the Geological Society of America, held in Tulsa. This paper is to be published soon. In it the additional confirmatory evidence was presented, the importance of the "profile of weathering" as a criterion of interglacial intervals was emphasized, the post-Illinoian loesses were dated and their relationships, sources and conditions of deposition were discussed and a picture of the development and retreats and readvances of the major Wisconsin ice-fields was presented. New names for three of the subdivisions of the Wisconsin were proposed to replace those presented at the Toronto meeting and published in the *Journal of Geology*, which had been chosen with respect to the fields of ice accumulation rather than areas where the stratigraphic units may be studied, and which have since been found to be preempted. New names are, therefore, necessary.

The names which were withdrawn were Manitoban (Iowan), Quebecan (early and middle Wisconsin) and Hudsonian (late Wisconsin). The old name Iowan was retained, and the new names proposed were Tazewell, Cary and Mankato for the subdivisions shown in the following table. The name Tazewell is taken from Tazewell County, Illinois, where the Early Wisconsin deposits are well shown in their relations to the underlying Peorian loess. The name Cary is taken from a town in McHenry County, northeastern Illinois, where the Middle Wisconsin deposits are well displayed. The name Mankato is taken from Mankato, Minnesota, where the Late Wisconsin deposits are excellently displayed.

Age	*Subdivisions*	
Wisconsin (Fourth) glacial	Mankato	(Late Wisconsin)
	Cary	(Middle Wisconsin)
	Tazewell	(Early Wisconsin)
	Iowan	
Sangamon (Third interglacial)		
Illinoian (Third glacial)		

M. M. LEIGHTON
ILLINOIS STATE GEOLOGICAL SURVEY

"MESCAL PITS"—A MISNOMER

SCIENTIFIC nomenclature has always been cumbered with a large number of inappropriate and inadequate terms, some due to a creeping in of temporary designations which were never intended to survive the laboratory stage and others due to a lack of understanding during early investigations in new fields. One of the newer scenes of effort in the field of Southwestern archeology has lately come to notice through the work of representatives of the U. S. National Museum, the Museum of the University of Pennsylvania and the Laboratory of Anthropology. The area in reference consists of the extreme southeastern part of New Mexico and the adjoining portion of southwestern Texas. Among the prominent features which distinguish one of the prehistoric cultures in this area, the principal habitat of which seems to be in the mountain ranges bordering the lower Pecos Valley on the west, are curious structures of open circular form, composed principally of small fragments of fire-cracked limestone. These circles occur abundantly in favorable locations from a point near Hope, New Mexico, in the foothills of the Sacramento Mountains, south throughout the Guadalupe and Davis Moun-

[1] Volume 39, No. 1, pp. 45–53, 1931.

tains for an as yet undetermined distance into Texas. The name "mescal pit" has been applied locally to this type of structure over a period of many years, and the use of this term has spread equally with the interest incited by the recent investigations. For the two field seasons of 1930 and 1931 the writer conducted expeditions for the Laboratory of Anthropology in the Guadalupe Mountains area, and during this time a number of "pits" were excavated or trenched. It was definitely determined that they were not pits, in any sense of the word; nor were they concerned especially with the preparation of mescal for food. Instead, they were found to be specialized refuse heaps. These circular mounds contained, in addition to the more obvious small cracked rocks, accumulations of ash, charcoal, food bones and other camp debris. As the term "mescal pit" is obviously a misnomer, and as it is likely to be perpetuated by usage, the writer feels that a designation more in keeping with the character of the structures should be chosen. Therefore the name "midden circle" is proposed. Further discussion of these circles, together with other archeological information gathered during the two seasons' work, will appear in a report now in preparation.

H. P. MERA

LABORATORY OF ANTHROPOLOGY
SANTA FÉ, NEW MEXICO

IS GEOLOGY EASIER FOR BOYS THAN FOR GIRLS?

IN an article which appeared in the issue of SCIENCE, dated November 11, 1932, and written by Gragg Richards, of Detroit, Michigan, evidence based on statistics was introduced to prove that geology is an easier subject for men than for women. I have examined the grades of all the students who have taken my course in physical geology for the past seven years. They come from all the classes in college, ranging from 17 to 21 years of age, the larger proportion from the freshman and sophomore classes. Instruction consists of lectures, laboratory work and field trips. A standard college text-book is used, and students are required to supplement class work by outside reading; 10 to 25 readings constituting the usual number, the smaller figure being the minimum required. The average size of the laboratory section is about 25 and there is considerable personal contact between instructor and student, especially in the laboratory and in the field. The grades for the course are on the following basis: A—excellent, B—good, C—fair, D—unsatisfactory, F—failure. No conscious effort was made to follow a distribution curve. The group consists of 647 students, 254 men and 393 women. On the basis of A = 3, B = 2, C = 1, D = 0, the men show an average of 1.255 and the women 1.407.

	Percentage				
	A	B	C	D	F
Men (254)	6.3	30.25	46.1	11.4	5.92
Women (393)	8.9	36.6	40.7	10.7	3.06
Entire group (647)	7.6	33.42	43.4	11.0	4.49

These statistics show clearly that the women are slightly better than the men, although the difference between them is so slight that one may consider them equal in ability. They also indicate that geology is as easy for women as for men. There is, in my opinion, based on eighteen years of experience teaching science, no marked difference in the ability of men and women.

KARL VER STEEG

COLLEGE OF WOOSTER

BROWN ROOTROT OF TOBACCO

A FORM of brown rootrot of tobacco is due to the insufficient intake of calcium by the tobacco plant. The condition may be brought about by lack of available calcium, an excess of magnesium over calcium or the presence of appreciable amounts of ammoniacal nitrogen in relation to nitrate nitrogen. The foregoing findings were the results of researches carried on at the Connecticut Agricultural Experiment Station at New Haven and the Tobacco Substation at Windsor, Connecticut. Soil, sand, water cultures and field tests were made.

T. R. SWANBACK
H. G. M. JACOBSON

AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONNECTICUT

SCIENTIFIC BOOKS

RECENT ZOOLOGICAL TEXT-BOOKS

IN reading the text-books which have been published during the latter part of 1932 a reviewer is impressed by certain facts which are perhaps worth mentioning: (1) Writers of text-books are unprogressive. They have at last given up Batrachia, Urodela and Anura; and use Amphibia, Caudata and Salientia, instead. But they cling to such archaic names as Platyhelminthes, Nemathelminthes, Trochminthes, Molluscoidea, Pelecypoda, Polyzoa and Infusoria. Even such a conservative institution as the *Zoological Record* has progressed to Platyhelminthia, Nemathel-

minthia, Ciliophora and Bryozoa. All biology does not have to be crammed into two great receptacles, morphology and physiology. Such a subject as psychology perhaps depends as much upon knowledge of the structure of neurones, tracts and areas as upon that of behavior, reflexes and reaction times; but two recent writers assert that psychology is (in the words of Octavius Roy Cohen) "nothing else but" physiology. The scientific name of an animal consists of the genus, species *and the name of the author;* but a student in elementary zoology has no chance to find this out. (2) A glossary should be a series of carefully considered, critical definitions of technical terms, instead of a list of careless, loose and inaccurate statements, such as a freshman might produce impromptu during an oral quiz. (3) Generic names are sacred and their spelling may not be changed to suit the whims of writers. Amoeba can not become ameba. (4) High-school teachers appear to be doing better teaching than university professors. Their texts are written for students to read and use; not for professional, backward-looking zoologists. Students in high schools are expected to solve problems, think and grow—not merely verify, draw, answer, pass and get credit.

Animal Biology. By LORANDE LOSS WOODRUFF. Macmillan, New York. $3.50. xii + 513. 1932.

This text-book presents zoology from "a general biological view-point." It is the work of a scholarly man who shows his general learning by frequent, apt quotations. Good judgment is shown in the use of technical terms; there are not too many, but enough are introduced to permit a student to gain some knowledge of zoological terminology. The book is well planned; the figures are well conceived and executed. The parts of the work that relate to general biological phenomena are well presented; though frequently stated in a teleological way. Those that deal with classification and newer knowledge in fields with which the writer is apparently not familiar are often uncritical and inaccurate. For example, Chapter III, on the physical basis of life, is admirable; Chapter VII, "Survey of Invertebrates" is not so well done; the part of the appendix which deals with classification is quite unprogressive; the glossary contains many questionable statements. On page 80 it is said that, "The Guinea worm, Filaria, is sometimes six feet long, and spends its adult life under the human skin and its youth in a Water-flea." Since the time of Reichard in 1759 the guinea worm has been placed in the Genus Dracunculus and it probably never reaches a length of six feet. Other examples of objectionable statements are, "the Earthworms, or Oligochaeta. . . . The largely sedentary and nocturnal life of earthworms renders special locomotor, respiratory, and sense organs unnecessary," (p. 81); "Absorption. The passage of nutritive and other fluids into living cells. . . . Alternation of Generations.—The alternate succession of a sexual and an asexual generation in the life history" (p. 473); "Chorion.—External embryonic membrane of Mammals. . . . Cloaca.—A cavity at the posterior end of the Vertebrate body. . . . Colony.—An aggregation or intimate association of several or many similar individuals to form a superior unit" (p. 476). Evidently the writer disapproves of the modern tendency to begin even generic names with small letters, for he begins even such words as Man, Bird and Butterfly with capitals. The topics discussed in the twenty-five chapters are: The scope of biology, cells, physical basis of life, metabolism, protozoa, metazoa, invertebrates, vertebrates, nutrition, respiration, circulation, excretion, reproduction, coordination, origin of life, continuity of life, fertilization, development, inheritance, adaptation, descent with change, biology and human welfare, and the development of biology.

Manual of Animal Biology. By GEORGE ALFRED BAITSELL. Macmillan, New York. $2.50. xiii + 382. 1932.

This is a laboratory manual intended to be used with Woodruff's "Animal Biology" and other standard zoological text-books, to which references are made throughout. It consists of two parts, "descriptive" and "laboratory directions" (which are also descriptive). The first part contains brief accounts of protoplasm, amoeba, euglena, volvox, paramecium, vorticella, grantia, hydra, obelia, starfish, earthworm, crayfish, insects, clam, frog and vertebrates in general, and vertebrate development. The second part, on detachable pages, contains laboratory directions concerning equipment, microscope, cells, green plants, fungi, protoplasmic movement, amoeba, euglena, volvox, paramecium, grantia, hydra, obelia, gonionemus, starfish, earthworm, crayfish, grasshopper, honey-bee, life history of moth, clam, chordates, vertebrates, tissues (epithelial, muscular, supporting), vertebrate skeleton, viscera, buccal and respiratory organs, enteron, vascular system, urinogenital system, nervous system, histology of nerves, tissue, vertebrate eye, spermatogenesis, oogenesis, fertilization, mitosis, and embryology of frog and chick. The method employed in each exercise is the observation of such structures as are described and the making of one or more drawings. Apparently no written notes are expected and no questions are asked. Twelve figures are presented.

An Introduction to Zoology Through the Study of the Vertebrates with Special Reference to the Rat and Man. By ZENO PAYNE METCALF. Thomas: Springfield, Illinois. $3.50. xx + 426. 1932.

This book has been written for agricultural students in general zoology and is presented in "three major divisions: (1) a general introduction; (2) the study of the detailed anatomy and physiology of a mammal, the rat, with comparisons from other groups of vertebrates; (3) the broader aspects of zoology. . . . Throughout this text-book the author has attempted to write on what he believes is the level that the average college freshman can attain. . . . It has not been written for zoologists but for beginning college students." The book appears to have been thoughtfully and carefully written. The figures are clear and appropriate. Classification receives little attention; morphology, physiology and the general aspects of biology and economic zoology are emphasized. The scope of the work is indicated by chapter headings in the three sections: (1) The field of zoology and the animal kingdom; (2) with special reference to the rat and mammals—general morphology and physiology; habits, external characters, general internal structure, integument, muscles, skeleton, locomotion, enteron, respiratory system, urinary system, circulatory system, metabolism, reproductive system, embryology, heredity, endocrine system, nervous system; and (3) distributional zoology, paleontology, evolution and history of zoology.

Zoology. By F. E. CHIDESTER. Van Nostrand, New York. $3.75. xii + 581. 1932.

In the preface of this book it is said that, "this text was written as a general survey for use by college students and to serve as a reference book by biologists. . . . Important features are the logical arrangement of facts about the animals within a group, a statement of the chief characteristics at the beginning of the discussion, and a summary of the economic importance at the end of each section. The newer physiology has been introduced and a bibliography checked by experts in each field is given at the end of each chapter." To the reviewer the book seems to be poorly organized and poorly written. It contains many questionable and inaccurate statements. For example, under the title "Characteristics" the following statements are made about Protozoa (p. 21): 1. Morphologically the simplest ones are equal to isolated epithelium. 2. Physiologically they are equal to the whole group of cells making up the human body. Protozoa are complete unicellular organisms and many have a brief multicellular phase. 3. Functionally they epitomize life processes. 4. Theoretically they are generalized cells. 5. Of practical economic importance, they cause many diseases. 6. As soil organisms protozoa are of doubtful importance.

Are the points enumerated characteristics and do they all mean something? In characterizing the vertebrates (p. 14) nothing is said concerning gill slits, but invertebrates (p. 16) are said to "lack gill slits or visceral clefts." "The term 'tropism' has long been used to indicate the reaction of an animal to some sort of stimulus," (p. 24) is an example of many loose statements. Two species of amoeba are said to occur in man (p. 26); whereas eight or more so occur. *Christispira,* a spirochaete, is affirmed to be "a large flagellate" (p. 29). The glossary contains many doubtful and curiously limited statements—*e.g.: "dentine,* the inner portion of a tooth; *lipoid,* a substance found in the nervous system which is dissolved by anesthetics or narcotics; *respiration,* oxidation of protoplasm releasing energy and producing carbon dioxide; *testis,* an organ in a male animal where sperms are produced." The twenty-two chapters are devoted to Introduction, Protozoa, Porifera, Coelenterata, Platyhelminthes, Nemathelminthes, Annelida, Trochelminthes, Molluscoidea, Echinodermata, Mollusca, Arthropods, Chordata, Cyclostomata, Pisces, Amphibia, Reptilia, Aves, Natural History of Mammals, Mammalia—Physiology, Social Life of Animals, and Evolution, Heredity, and Eugenics.

The Essentials of Biology. By JAMES JOHNSTONE. Longmans, Green and Co., New York. xv + 328. 1932.

"The intention of this book is to present a balanced account of the theoretical matter of animal biology. Botanical results are only noted in so far as they bear upon general biological science." The book is a thoughtful, philosophical consideration of modern science with special reference to biology. It is not a catalogue of facts to be learned, but a logical development of thoughts and relations. The statements made are carefully considered and mean something. At times they may be a little tiresome and abstruse, but the reader gains much and feels repaid. When scanning the book one wishes that college students in the United States could have more of the attitude of mind that would be essential for its use—more thoughtful consideration of the fundamental problems of science and less concern for memorized facts and propaganda. Johnstone's book may be read with profit by any student, young or old. It is in two parts and nine chapters, which indicate the contents: (I) THE INDIVIDUAL, (1) the Organism as a Natural Thing, (2) Organic Structure, (3) Organic Functioning, (4) Animal Behavior; (II) THE RACE, (5) Reproduction and Growth, (6) Development, (7) Heredity, (8) Transformism, and (9) the Evolutionary Career.

Everyday Problems in Biology. By C. J. PIEPER, W. L. BEAUCHAMP and O. D. FRANK. Scott, Foresman and Company, Chicago. $1.60. xxxiii + 686. 1932.

This is a biological text intended for use by high-school students in the ninth and tenth grades. It is a carefully considered, well-organized book written by experienced teachers. The student is stimulated to think about things biological, especially those related to man, and his capacity is continually increased. Topics are considered under twelve "units," presented as questions, in the following order: obtaining and using food, growth, reproduction, ecology, behavior, classification, economic biology, evolution and conservation.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

IMPROVED KYMOGRAPH RECORDING

SINCE the introduction of smoked, glazed paper for kymographic recording, numerous attempts have been made to obviate many of the disadvantages of this method. Of these attempts the most recent have been the successful efforts of Wichart, Thienes and Visscher,[1] and Patterson.[2] The former group of investigators employ cellophane coated with carbon sprayed from a pressure air gun, whereas Patterson delivers ink from quill pens against white, glazed paper. The former method allows for direct reproduction in the lantern by simple insertion between two glass plates but still retains the disadvantage of requiring carbonizing before and fixing after recording. Patterson's method simplifies preparation of a record which requires no shellacking but requires photographing for reproduction in the lantern.

More recently Warren[3] reported the use of cellophane as a transparent preparation, capable of receiving impressions from carbon paper in the typewriter or by pencil pressure. He cautions, however, against handling, which removes the carbon particles from the cellophane.

We have found cellophane an excellent recipient for India ink, which dries almost immediately and resists violent finger friction. Cellophane also takes red, blue and green ink (concentrated by evaporation to one half or one third volume), and thus allows for differential tracings to be made of any type of drawing, photograph or record.

We have further utilized the ink-taking properties of cellophane in keeping permanent records of physiological activity to be kymographically registered. Curved glass capillary tubes of very fine bore deliver ink to the cellophane, which is held in position on the kymograph drum by library paste or rubber bands. To afford less chance of breakage capillary tubes can also be bent to lead ink to the inner surface of ordinary steel writing pens, which are supported on light reed or aluminum recording levers. To render the record easily discernible, the drum is first covered with permanent white facing—either enamel or paper.

This type of cellophane record requires no smoking nor fixing. The ink will not rub off unless it is moistened with water or alcohol, in which case the cellophane will retake ink at site of removal. Any part of the permanent record, as suggested by others,[1, 3] can be placed between glass plates and used directly in the projection lantern. The economy of the method, obviating smoking, shellacking and photographing parts of records, is apparent.

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[1] W. F. Wichardt, C. H. Thienes, M. B. Visscher, SCIENCE, 73: 99, Jan. 23, 1932.
[2] T. L. Patterson, Demonstration, The Federation of Amer. Societies for Exp. Biol. Philadelphia, April, 1932.
[3] K. L. Warren, SCIENCE, 76: 573, Dec. 16, 1932.

AN INEXPENSIVE PYROMETER FOR TEMPERATURES UP TO 1000° C

THE use of an electrical muffle furnace in operations such as ashing of biological materials makes the control of temperatures up to 1000° C. highly desirable. Finding most manufactured pyrometers expensive we originally fashioned a simple thermocouple of chromel-alumel and calculated the temperature from e.m.f. as measured by a student potentiometer. Subsequently we used an inexpensive microvoltmeter procured through the Weston Electrical Instrument Corporation, Newark, N. J., who were kind enough to modify one of their standard instruments (Model 301) and equip it with a scale calibrated in centigrade degrees, the entire assembly making a direct reading pyrometer with a range up to 1000° C. accurate to $\pm$ 10° C. and obtainable at nominal cost.

No. 14 gauge pieces of chromel and alumel wires each about 3 ft. long were twisted together tightly for a distance of one inch. The twisted ends were protected from corrosion by means of a small silica test-tube packed with asbestos fiber. The free ends were insulated from each other by short lengths of silica tubing sufficient to bring the wires out of the back of the oven and were held in position far enough from the oven to avoid being heated by radiation. They were then connected to copper leads, which ran to the reading instrument. Changes of ambient temperature about this junction were not compensated for, and, for the accuracy desired, could be neglected. The modified microvoltmeter was made for us by the

Weston Electrical Instrument Corporation when we had furnished them with the following information: Nature of the thermocouple, range of temperature desired and total resistance in ohms of the thermocouple and its leads. Comparison of the readings of this instrument with the calculated temperature from e.m.f. measurements from room temperature to 1000° C. agreed to within ± 10° C. As the temperature of various points within the oven may vary by as much as ± 25° C., this accuracy is quite adequate.

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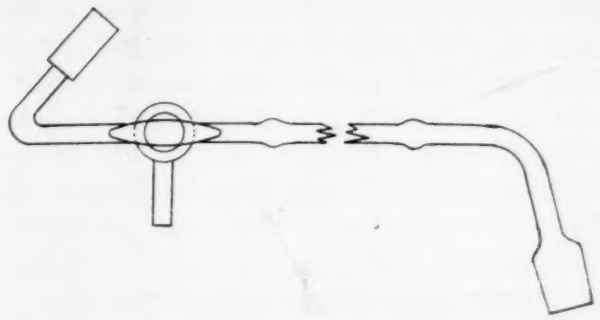
MODIFICATION OF THE BACKLIN-KIRK COMBUSTION CHAMBER FOR MICRO-DETERMINATION OF CARBON AND LIPOIDS

IN the manometric determination of lipoids the combustion chamber is highly evacuated at the time it is to be removed from the Van Slyke manometer. In the original Backlin chamber[1] a stop-cock is present at the top of the combustion chamber which may be opened at this time to relieve this pressure which facilitates removal of the rubber connection to the manometer. At best this operation involves some risk of damaging the manometer. The chamber, as modified by Kirk,[2] has eliminated this stop-cock, thus necessitating removal of the rubber connection against the low internal pressure of the chamber. A simple method of reducing the hazards of such procedure is to add a three-way stop-cock (*cf.* diagram) in the



delivery tube of the chamber. After the upper cock of the Van Slyke absorption chamber has been closed this stop-cock may be turned to admit atmospheric pressure before detaching the delivery tube.

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SPECIAL ARTICLES

A PROOF OF THE LAW OF EFFECT

PSYCHOLOGISTS and physiologists all agree that the behavior of man and of many other animals is modifiable by the experiences of life. He learns, so that the situation, S, which at first evokes, say, responses 1, 2, 3, 4 and 5 equally often, comes to evoke one response, say 4, always or ninety-nine times out of a hundred. The connection S → 4 has become enormously strengthened relatively to S → 1 or S → 2 or S → 3 or S → 5.

Concerning the forces producing learning there has been great disagreement. The writer (1898, 1914 and 1931) has maintained that the after-effects of a modifiable connection work back upon it, and that, in particular, a satisfying state of affairs accompanying or directly following a connection strengthens it. Troland maintained a similar doctrine.

The great majority of psychologists have maintained, on the contrary, that the strengthening of any connection is due to forces operating within the connection itself or prior to it. Repetition or frequency of occurrence, recency, intensity, finality or consummatoriness, tendency to attain equilibrium, and other features of the process have been alleged to be adequate to explain the strengthening of connections.

I have presented recently evidence from a variety of experiments to show that a satisying after-effect of a connection does in fact strengthen it under conditions equalized in respect of all other forces than the satisfying after-effect.[1] It is the purpose of this report to present an entirely independent experimental proof of the strengthening influence of a satisfying state of affairs upon the connection of which it is the after-effect and important new facts concerning the method of action of that influence.

We provide in an experiment a long series of situations to each of which several responses are possible, one of which is arbitrarily followed by a reward, any other being followed by a punishment. For example, a series of words is said by the experimenter, to each of which the subject may respond by any number from 1 to 10. If he says the number that has been chosen to be "right" he is rewarded; if he says any other, he is punished. So we have a long sequence of connections and after-effects, in the form Word 1 → number, reward or punishment, Word 2 → number, reward or punishment, Word 3 → number, reward or punishment, Word 4 → number, reward or punishment, etc.

[1] E. Backlin, *Biochem. Zts.*, 217: 483, 1930.

[2] Peters and Van Slyke, "Quantitative Clinical Chemistry-Methods," Williams and Wilkins, 1932.

[1] "The Fundamentals of Learning," E. L. Thorndike, 1932.

This series is repeated again and again. We quote the results for the first ten words in trials 1 to 4,[2] from a sample record.

	Trial or round 1	Trial or round 2	Trial or round 3	Trial or round 4
catnip	2	4	10	2
cedar	3	3	6	2
chamber	1	2	9	8
chorus	8	10	7	6
dally	4	8	5	4
dazzle	C2	6	9	1
debate	9	7	2	5
deduce	5	2	2	2
early	4	C5	C5	C5
effort	3	6	C7	C7

The time-intervals were as follows: One unit of the series from word to word or number to number took about 2.2 sec. The time from the announcement of "Right" or "Wrong" to the approximate mid-point of the word–number connection to which it belonged was about 0.5½ sec. The time to the mid-point of the next preceding connection was about 2.8 sec., to the next, 5.0 sec., to the next, 7.2 sec., and so on. The time to the mid-point of the word–number connection following the announcement of "Right" or "Wrong" was 1.7 sec. The time to the next following was 3.9 sec.; to the next, 6.1; and so on.

In such a series the rewarded connections are strengthened, but that fact is not our present concern. The fact to which I invite attention now is that the punished connections do not behave alike, but that the ones that are nearest to a reward are strengthened most. The strengthening influence of a reward spreads to influence positively not only the connection which it directly follows and to which it may be said to belong, but also any connections which are near enough to it. We may measure nearness in terms of time or in terms of number of connections or steps. Thus the punished connection *catnip* → *2* in Trial 1 preceded the reward for *dazzle* → *2* by about 11.6 seconds and by 5 connections or steps. The punished connection *cedar* → *3* in Trial 1 preceded the reward of *dazzle* → *2* by about 9.4 seconds and by 4 connections or steps. The punished connection *dally* → *4* in Trial 1 preceded the reward of *dazzle* → *2* by about 2.8 seconds and by one connection or step.

The amount of strengthening is measured by the percentage of repetitions in the following trial. For example, for the ten subjects of the experiment chosen as an illustration we find the following for punished connections alike in all respects save their proximity to a reward:

	N	Percentage of repetitions in the following trial
One step removed	4136	26.4
Two steps removed	2250	23.6
Three or four steps removed	1933	21.0
Five or more steps removed	1228	20.8
Three or more steps removed	3161	20.7

For 905 connections like these in all respects, save that a reward directly followed and belonged to them, the percentage of repetitions was about 50.

In such experiments the fact that a person responds to a word by a certain number makes him more likely to respond to that word at the next trial by that same number, even though the response was punished. The connection is strengthened more by being made than it is weakened by being punished. This has been indicated by Thorndike ('32, p. 112, and p. 280ff), and demonstrated by Lorge in articles to appear shortly in the *Journal of Experimental Psychology* and by the present series of experiments. The best measure of strengthening due to one occurrence of a punished connection at some specified proximity to a reward is then the excess strengthening over that due to one occurrence of a punished connection so remote from a reward as to receive zero influence from it. In the illustrative experiment those excesses are 5½ for one occurrence of a punished connection one step away from a reward, and 2½ for one two steps away.

We have made fifteen experiments, using various sorts of learning. The results show that a satisfying after-effect strengthens greatly the connection which it follows directly and to which it belongs, and also strengthens by a smaller amount the connections preceding and following that, and by a still smaller amount the preceding and succeeding connections two steps removed.

One occurrence of a rewarded connection produces an average excess strengthening of 22 (per hundred) with a probable error of 3. One occurrence of a punished connection next to and preceding a rewarded connection produces an average excess strengthening of 4 (per hundred) with a probable error of 0.4. A punished connection occurring after a rewarded connection receives an excess strengthening of about 5 (per hundred). A punished connection between two rewarded connections receives an

[2] In this experiment the series of words, each with its "right" number, was read to the subject first, so that correct choices even in the first round would be a matter of ability plus chance rather than of chance alone.

excess strengthening of 7½ per hundred. Punished connections two steps and 5 or more seconds away from a rewarded connection are influenced favorably by it.[3]

The proof that a satisfying after-effect strengthens directly the connection producing it, and also other connections in close proximity to it, is important, because it explains selective modifiability. It solves many problems for which the forces of frequency, recency and intensity are inadequate. It accounts for the true contentions of purposivism without recourse to mystical agencies.

The physiological explanation of the influence of a satisfying after-effect is as yet unknown, just as the physiological explanation of the influence of mere repetition of a connection is unknown. But we can now proceed to find out facts about the former which may lead us to a physiological explanation of it, and which are valuable in any case.

Thus, Dr. Rock has measured the effect of differences in the intensity of the reward. I have measured, though as yet very imperfectly, the effect of differences in the time-interval between the connection and its reward. I have measured the effect of differences in the relevance of the reward. Dr. Lorge is proceeding to measure the influence of an occurrence that is neither rewarded nor punished, so that we may compare the strengthening by it with the strengthening by various after-effects.

I can already frame a physiological explanation which demands little more from the nervous system than any doctrine of facilitation demands. And I venture to prophesy that the physiology of strengthening by the after-effects of a connection will be understood sooner than the physiology of strengthening by its sheer repetition.

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IS MALIGNANCY DUE TO A PROCESS ANALOGOUS TO SOMATIC MUTATION?

MALIGNANT tumors develop in the walls of parasitic cysts of *Cysticercus fasciolaris,* the larval stage of *Taenia taeniaeformis* (*crassicollis*), the common tapeworm of the cat. Tumors have been produced experimentally by feeding rats *Taenia* eggs derived from cat feces. The shells of these eggs are digested off in the rat's intestine, and the oncospheres attach themselves to the wall of the intestine, work their way into the blood vessels of the gut wall and are carried to the liver by the portal circulation. They are strained out in the liver capillaries and grow rapidly forming clear vesicles, which about the seventh day become visible to the unaided eye.

At this stage some of the larvae have been transplanted to the subcutaneous tissues of other rats, but for the most part they have been allowed to continue their development in the liver. In either locality the growing larvae initiate considerable proliferative activity in the surrounding tissues which results in the formation of fibrous cyst walls. After from 8 to 27 months the cells of these cysts may show active and often atypical proliferation and may undergo malignant changes.

Most of the tumors produced have been polymorphous cell sarcomata, spindle cell sarcomata or a mixture of the two. The rarer tumors were of the following types: fibroma, chondroma, osteochondroma, chondrosarcoma, osteochondrosarcoma, fibrosarcoma, liposarcoma, adenoma and carcino-osteochondrosarcoma.

At the beginning of the present analysis (June, 1932) 52,223 rats from completed pedigreed matings had been autopsied. Of these 26,172 were infested with the parasite, 13,120 had survived the infestation for at least eight months (the minimum period of infestation observed in the case of a bearer of a *Cysticercus* sarcoma) and 3,285 had *Cysticercus* sarcoma. Besides these, 68 purchased animals and 316 of the unpedigreed descendants of purchased animals had the malignant complication of the *Cysticercus* disease.

Taenia eggs from cats obtained from various parts of the city and suburbs and others infested in the laboratory were equally effective in producing the disease and the associated malignant tumor, but rats showed marked strain and family differences in the proportion of individuals which developed both the disease and the complication.

Early in the experiments it was noted that the duration of the irritation (that is, the residence of the parasite in the liver) before the appearance of the malignant phase of the *Cysticercus* disease varied over a period of 19 months, which is half the maximum life span of our laboratory rats. Furthermore, the proportion of tumor bearers increased directly from the eighth to the twentieth month of infestation. It was also noted that usually only one cyst and in some of the early tumors only a small area of the cyst wall showed the malignant transformation, although the host might have had one to one hundred other cysts which were benign. Occasionally two or more apparently independent *Cysticercus* tumors occurred in the same host.

The clue to the explanation of the strain and family differences and to the variations in the duration of infestation appeared in the present analysis, when it was observed that in the 3,669 bearers of

[3] The detailed results for all the experiments will be published at an early date.

Cysticercus sarcoma there was a significant negative correlation ($-.527 \pm .008$) between the number of cysts in the liver and the duration of infestation with the parasite. It follows that if the bearers of *Cysticercus* sarcoma are distributed according to the number of parasitic cysts, a general decrease in the duration of infestation is observed with each successive increase in the number of cysts. Also the mean age at autopsy of these tumor bearers is parallel to the duration of infestation and in each case exceeds it by approximately two months, the average age at which the rats were infested. For each number of cysts the mean duration of infestation and mean age are slightly higher for females than for males, but in many cases the differences are not statistically significant. The essential factor is the duration of the irritation and not the actual age of the rat. This is shown when the tumor bearers are classified according to the age at which they were infested, for the mean age at autopsy rises proportionately with the age at which they were fed *Taenia* eggs; but the duration of infestation remains constant instead of decreasing directly with the age fed, as would be expected if age were the important factor. The mean duration of infestation not only became shorter but also became less variable with the increase in the number of *Cysticercus* cysts. This is shown by a gradual decrease in the standard deviations of the duration of infestation.

If the frequencies of rats infested with successive numbers of cysts are cut off at the mean period of infestation for tumor hosts with the corresponding numbers of cysts, and the percentage of tumor bearers among these is calculated, it is observed that the proportion of tumor bearers increases almost directly from 31.5 per cent. of the individuals with one cyst to 85.7 per cent. of those with 50 cysts. Above 50 cysts the number of rats in each group is small, since such large numbers of parasites are detrimental to the host. Nevertheless, in general the proportion of tumor bearers continues to increase with increase in numbers of cysts, and in several cases reaches 100 per cent. of the survivors of the *minimum* period of infestation. The males show a tendency to a slightly higher percentage of tumor bearers than the females, but in most cases the difference is not statistically significant.

If the different strains are considered separately, it appears that they all show the same general tendency to an increase in proportion of tumors with an increase in the numbers of parasites, but in some the increase is more rapid than in others. Furthermore, if in each strain the number of infested rats which reached the mean period of infestation for tumor bearers with the corresponding number of cysts is summed for the successive numbers of cysts, and the percentage of these which were tumor bearers is calculated, a marked difference is observed between certain strains. It can be demonstrated that this difference is determined by two factors, relative longevity and susceptibility to *Cysticercus* disease. That is, those strains which show a low proportion of tumor bearers show a low average length of life and a marked resistance to the *Cysticercus* disease, while the strains with a high proportion of tumor bearers show either a long average life span or a high degree of susceptibility to the disease.

Since an increase in the number of cysts, that is, an increase in the surface exposed to the irritant, decreases directly the time interval necessary for the onset of the malignant process and increases directly the probability of its occurrence until it becomes inevitable, it is apparent that *chance* is an important factor in the change of a normal to a *cancer* cell. Further, in the case of *Cysticercus* sarcoma hereditary factors influence the occurrence of malignancy only as they influence susceptibility of the individual to *Cysticercus* disease and longevity. Possibly when more is known about the etiology of other tumors for which there appears to be an inherited susceptibility and when the expression of genetic factors in the cells and tissues is better understood, it will be found that in the case of all neoplasms in all species the initial cell change occurs by a process analogous to somatic mutation and that hereditary factors determine this change only in so far as they influence longevity and the susceptibility of an individual to some specific irritant or condition which is favorable to mutation.

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COLUMBIA UNIVERSITY

BOOKS RECEIVED

Carnegie Institution of Washington. Year Book No. 31, 1931–32. Pp. xix + 392. The Institution.

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LOGSDON, MAYME I. *Elementary Mathematical Analysis.* Vol. II. Pp. ix + 188. 74 figures. McGraw-Hill. $1.75.

MERRIAM, JOHN C., and CHESTER STOCK. *The Felidae of Rancho La Brea.* Pp. xvi + 231. 42 plates. 152 figures. Carnegie Institution of Washington.

NOWLAN, FREDERICK S. *Analytic Geometry.* Pp. xi + 295. 159 figures. McGraw-Hill. $2.25.

RAYMOND, ALLEN. *What is Technocracy?* Pp. vii + 180. Whittlesey House, McGraw-Hill. $1.50.

Tokyo Bunrika Daigaku. Science Reports. Vol. I, No. 4: Pp. 41 + 59; Vol. I, Nos. 5–10: Pp. 61–131. Tokyo University of Literature and Science.

TURCK, FENTON B. *The Action of the Living Cell.* Pp. xi + 308. 17 figures. Macmillan. $3.50.